TECHNICAL REPORT
NATICK/TR-90/055

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TECHNICAL OBJECTIVE DOCUMENT FOR FOOD AND FOOD SERVICE SYSTEMS

BY
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UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

FOOD ENGINEERING DIRECTORATE
ENGINEERING PROGRAMS MANAGEMENT DIRECTORATE

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This document provides information on the Army's technical objectives for the Food and Food Service areas to the external community, both Government and nongovernment, including academic, scientific and industrial organizations. Its purpose is to stimulate the participation of such organizations in Army research and development. Areas covered include:

Management

Technology Base Investment Strategy

Technical Objectives

Progress and Accomplishments

Planned Programs (research, technology and development)

Scientific and Technical Areas of Interest

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PREFACE

This report was produced during the period October 1988 to April 1989, under the Program Elements 61102,62786,63747,63001 and 64713.

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I. INTRODUCTION

The U.S. Technical Objective Document is an important part of the Army's Information for Industry Program. Each Army laboratory and research, development and engineering center has an opportunity to periodically prepare a Technical Objective Document based upon Department of Defense user requirements, scientific and technological opportunities, and the needs of present and projected systems.

We all recognize that the developments and accomplishments of the Department of Defense (DoD) are the product of teamwork among DoD scientists and engineers and their counterparts in industry and the academic community. This document is intended to increase this teamwork by providing you with necessary information on Natick's research, development and acquisition program. Specific objectives are:

To provide planning information for independent research and development programs.

To improve the quality of unsolicited proposals and Broad Agency Announcement proposals and Research and Development procurements.

To encourage face-to-face discussions between Army engineers and scientists and their external counterparts.

As you read through the pages that follow, you may see an opportunity to which your organization can respond. We invite you to discuss the opportunity with the scientist or engineer identified by name. Furthermore, you may have completely new ideas not considered in this document, which, if brought to the attention of the proper organization, could make a significant contribution to the Department of Defense's capabilities. The Department of Defense has a continuing interest in receiving proposals that contain new ideas, suggestions and innovative concepts for weapons, supplies, facilities, devices and equipment. In other words, your ideas, whether in response to this document or not, are always welcome.

Classified/limited distribution Technical Objective Documents are available from the Defense Technical Information Center, Alexandria, VA, 22304-6145, while unclassified/unlimited documents are available from the National Technical Information Service, Springfield, VA 22161. These documents, as well as additional information on doing business with the Army, are also available from the Army's Technical Industrial Liaison Offices.

II. MANAGEMENT OVERVIEW: U.S. ARMY NATICK RD&E CENTER

1. MISSION

The mission of the U.S. Army Natick Research, Development and Engineering Center (Natick) is to ensure maximum survivability, supportability, sustainability and combat effectiveness of individual soldiers and crews on the battlefield under worldwide environmental extremes.

Our goal is to provide the American soldier the best equipment for the best price through research, development, and engineering in the areas of Food and Food Service Systems, Airdrop Systems, Tactical Shelters, and Clothing and Individual Equipment. We are deeply committed to making all Service members the best equipped and best fed in the world.

2. ORGANIZATIONAL STRUCTURE

Natick is an element of the U.S. Army Troop Support Command, a major subordinate command of the U.S. Army Material Command. Natick is currently organized with three commodity-oriented directorates - - the Individual Protection Directorate, the Food Engineering Directorate, and the Aero-Mechanical Engineering Directorate; three technical support directorates--the Advanced Systems Concepts Directorate, the Soldier Science Directorate, and the Engineering Programs Management Directorate; and the requisite administrative support elements.

Our commodity directorates are responsible for planning, organizing, and conducting/overseeing all required research, development, and engineering in their assigned areas for the Army. In addition, for Food and Food Service Systems, the Food Engineering Directorate, Advanced Systems Concepts Directorate and the Soldier Science Directorate perform these functions for the entire Department of Defense.

3. PROGRAM AREAS

Natick's programs encompass the total spectrum of research -- exploratory, advanced, and engineering development -- and activities essential to standardization and production engineering in support of procurement.

Our efforts are focused primarily on three commodity areas and include several distinct fields of endeavor, all covered by the U.S. Army Materiel Command/ U.S. Army Training and Doctrine Command Combat Service Support and Special Operations Forces Mission Area Material Plan. These are:

FOOD ENGINEERING AND FOOD SERVICE EQUIPMENT	- Field Feeding Systems - Operational Rations (Individual and Group) - Ration Packaging Systems - Garrison Feeding Systems - Food Service Equipment
AIRDROP AND COMBAT SERVICE SUPPORT	- Advanced Personnel and Cargo Airdrop Systems - Hardened Shelter Systems - Tentage and Organizational Equipment Systems

COMBAT CLOTHING AND INDIVIDUAL EQUIPMENT

- Lightening the Soldier's Load
- Ballistic Protection
- Individual Chemical/Biological Protection
- Laser Protection
- Countersurveillance/Flame/ Thermal Protection
- Cold/Hot Weather Clothing
- Microclimate Conditioning Equipment

For the Department of Defense Food and Nutrition Resources, Development, Test, Evaluation and Engineering Program, the planning and prioritization process is conducted annually by the Department of Defense Food and Nutrition Research and Engineering Board and is fully coordinated with the users in all the Services. Its execution is effectively managed through the assignment of an Officer from each of the Services to Natick to ensure that the individual needs of the soldier, marine, airman, and sailor are accurately identified, communicated and expeditiously addressed.

4. PROGRAM GOALS

Our program goals are to:

Ensure maximum survivability, supportability, sustainability, and combat effectiveness of individual soldiers and crews at all times under all environmental conditions.

Be the Center of Excellence for research, development and engineering in operational rations and food service systems, combat clothing and individual protective equipment, tactical shelters and tentage, airdrop systems and organizational equipment.

Achieve major technological and system improvements on highest priority user-relevant programs and expedite fielding of these improvements.

Exploit the worldwide technology base programs that support development of Natick's Next Generation/Future Systems addressing major technology barriers.

Optimize the use of resources to enhance productivity.

Maintain a cohesive long-range Research and Development plan and a corporate strategy that achieve and sustain mission superiority.

III. TECHNOLOGY BASE INVESTMENT STRATEGY

Technology is the lifeblood of new and improved Department of Defense systems and equipment. However, technology can only be an effective force multiplier if the application is fielded quickly. Streamlined acquisition measures are used by Natick to shorten the time between proving a concept feasible and putting a system in the hands of the troops.

Exploiting new technologies to field affordable systems and equipment for the Department of Defense is a challenging process, one that is becoming institutionalized through comprehensive analysis and long-range planning. The Army's Long-Range Research, Development, and Acquisition Plan, Training and Doctrine Command Mission Area Development Plan and U.S. Army Materiel Command/ U.S. Army Training and Doctrine Command Mission Area Material Plan provide the means for articulating a strategy for overcoming battlefield deficiencies and a rational allocation of resources based on criticality of need. Natick utilizes these tools for planning Food and Food Service Systems for all of the Department of Defense without compromising the individual Services' planning processes.

The link between mission area strategies and technology base planning is a set of Next Generation and Future Systems. Next Generation Systems are those immediately beyond those currently in development, while Future Systems are those designed to meet user needs in the year 2000 and beyond.

Natick is the proponent for several Next Generation and Future Systems, including two food related Future Systems entitled "Combat Field Feeding System 21" and "Rapid Deployment Food Service Module," which are described in the Appendix. Next Generation and Future Systems are generally described in conceptual terms and provide a set of references and targets for technology base efforts needed by focusing on specific critical technological barriers.

Natick's technology base investment strategy is composed of four major elements:

1. NEXT GENERATION AND FUTURE SYSTEMS

Approximately 34 percent of our technology base resources (6.1 basic research, 6.2 exploratory development, and 6.3A proof-of-principle technology demonstration), are currently allocated in support of specific Next Generation and Future Systems. Next Generation Systems are the systems that will begin full scale development in the 1990s and will provide a fielded capability into the 21st century. Future Systems are capabilities that would potentially be developed in the early 21st century. For each system, the enabling technologies that could allow achievement of the capabilities desired have been identified. Programs and proof-of-principle demonstrations of prototypes (Technology Demonstrations) have been structured in a logical, time-phased manner.

2. EMERGING TECHNOLOGIES

The potential of some emerging technologies is so great that special visibility and management attention are warranted even when the application to a specific system is unclear. About 14 percent of the Natick technology base's total resources is dedicated to maturing such high-payoff technologies. In the food area, our key emerging technologies fall into the areas of shelf stable tray-type meals, food processing advancements, multifuel burners and flameless heating. In addition, there is a concerted effort, ongoing, in the area of biotechnology, with emphasis on developing biodegradable plastic food packaging.

3. SYSTEMIC ISSUES

Systemic Issues that face the food system user, such as shelf life extension and food safety, lend themselves to technological solutions, but often do not have a system focus. About 44 percent of our technology base resources are allocated for these kinds of issues to make sure they get the required attention.

4. SUPPORTING CAPABILITIES

Finally, our investment strategy allocates about eight percent of resources in support of analytic capabilities. These include front-end analyses, modeling and simulations, Automated Data Processing data base development, special purpose equipment, and other infrastructure items that ensure our continuing ability to execute quality Research, Development and Engineering programs and act as smart buyers across the entire spectrum of the material life cycle.

IV. FOOD AND FOOD SERVICE SYSTEMS

1. OVERVIEW

Food and food service equipment research and development for the Army, Navy, Air Force, Marine Corps and the Defense Logistics Agency is conducted at the U.S. Army Natick Research, Development and Engineering Center in Natick, Massachusetts to meet the unique feeding needs of the Armed Forces through a combination of in-house and contractual efforts.

The program is executed in the Food Engineering Directorate, the Soldier Science Directorate and the Advanced Systems Concepts Directorate, whose specific functions are summarized below:

FOOD ENGINEERING DIRECTORATE

The Food Engineering Directorate (FED) is responsible for design, development and evaluation of military rations and food service equipment, to fulfill the requirements of the Army, Navy, Air Force and Marine Corps as well as special requirements to support the Defense Logistics Agency. Response to identified needs of the above Services involves long-range research, item and system development, and engineering support to procurement agencies for food and food service equipment during the entire life of the item. The end product of FED's effort is Technical Data Packages (specification, drawings, etc), which are used to procure items from commercial suppliers.

The Food Engineering Directorate is divided into three product divisions and a support division. The product-oriented divisions are the Technology Acquisition Division, the Food Technology Division, and the Food Equipment and Systems Division.

The Technology Acquisition Division is structured and staffed to conduct basic research and exploratory development involving new technologies for military rations and food service equipment. Its function is to explore, assess, adapt, and refine new materials, equipment, foods and processing techniques as a basis for establishing new technological opportunities for exploitation to meet with mid- and long-term military feeding requirements. As with all Food Engineering Directorate Divisions, the emphasis on Research and Development conducted by Technology Acquisition Division is on military-unique requirements, for which there are no civilian counterparts. Exploratory and feasibility studies are conducted on new foods and new processing techniques needed to provide optimally configured and formulated field rations, which can be assembled from the minimum number of basic components, to meet specific operational/environmental needs. Objectives of studies on foods and processes include optimizing nutrient content, extending shelf life, improving product functionality, and reducing overall food costs. Research and engineering studies on food service equipment encompass diverse areas, including combustion technology, energy conversion technologies, robotics, electronics, material science, and sanitation technologies.

The Food Technology Division conducts exploratory development, advanced development and engineering programs on military food and packaging items and systems to meet current and future military feeding needs. Division responsibilities include development and testing of new or improved foods, food processes, and operational rations in response to specific requirements of the

Services. Disciplines include food technology, packaging technology and physical sciences. Product development and evaluation is focused primarily on operational rations for field uses. Commercial items are evaluated for suitability and utilized, if possible, or modified, if feasible, to meet any special requirements resulting from the unique military environment.

The Food Equipment and Systems Division is responsible for development, testing and fielding of new or improved food service equipment and systems in support of requirements from the Services. Their mission includes evaluation of commercial food service equipment and methods, including foreign military equipment, for applicability to military requirements. Advanced and engineering development tasks are accomplished through both in-house and contracted design, and fabrication of prototype equipment. Development of food service equipment encompasses all aspects of evaluation, including laboratory and field testing to assure that all requirements are met. In addition to specific equipment development and testing, this Division is responsible for managing the development of selected integrated systems as well. Systems engineering activities involve integration of components, i.e., food, packaging, preparation and serving equipment, into total feeding systems.

ADVANCED SYSTEMS CONCEPTS DIRECTORATE

The Advanced Systems Concepts Directorate combines the functions of advanced systems concept development and long-range planning to conceptualize the most advanced feeding systems for land, sea and air military missions.

Advanced Systems Concepts Directorate applies a systems approach, which combines appropriate statistical and mathematical modeling techniques with field experimentation wherever possible. The dual emphasis on "laboratory" analysis through mathematical modeling and simulation, as well as on field experimentation jointly conducted with Food Engineering Directorate/Soldier Science Directorate, is a relatively unique departure from traditional systems analyses in the military environment. This approach provides a determination of the benefits obtained in the existing system as well as a description of the proposed alternatives or changes to the system and a projection of their benefits. The field experiment then validates the expected performance of the selected alternative system(s) concept. The success of this approach has been demonstrated in the development and rapid adoption of a new food service system concept for aircraft carriers, the development and fielding of new concepts for field feeding, and the development and deployment of a new feeding concept for Air Force Ground Launched Cruise Missiles.

In addition to projects involving long term improvements to current or soon to be implemented combat systems, Advanced Systems Concepts Directorate is involved in a number of efforts to define "Next Generation/Future Systems."

These are concepts that look to the years beyond 2000 and the threats and warfighting concepts that will be needed to assure an effective fighting force in the future. One example is a project to explore concepts for undersea subsistence storage and resupply.

SOLDIER SCIENCE DIRECTORATE

The Soldier Science Directorate has the mission of science and technology leadership for all of Natick's products and systems in support of the individual soldier. The Directorate, a multidisciplinary research organization, draws from the behavioral, biological, physical, chemical, and engineering sciences to maintain a decisive edge in technology, to ensure the timely transfer of information to Natick's product Directorates, other Army research and development activities, industry, and academia. Its thrust in food science and technology is aimed at ultimately providing soldiers with acceptable, nutritionally complete, environmentally stable and microbiologically safe meals for the whole spectrum of operational scenarios of the integrated battlefield of the future.

The Directorate is organized into three divisions: the Behavioral Sciences Division, the Biological Sciences Division, and the Physical Sciences Division. The Behavioral Sciences Division provides human factors support to all projects and programs at Natick. Its Food Systems Human Factors Branch has responsibility for supporting ration design and development. Modern marketing research techniques are being introduced into the behavioral research efforts in order to develop sensory and behavioral rules, criteria, and limits for optimizing the acceptance of novel rations and to engineer into these rations desirable sensory characteristics that will ensure their acceptance and consumption in the targeted field environment. Artificial intelligence technology is being implemented to aid in configuring ration components that optimally meet the nutrition and load carrying requirements for a given mission. An expert system is being developed to aid soldiers who have to forage for food in strange and hostile environments.

The Biotechnology Branch of the Biological Sciences Division focuses on the development of new food packaging based on biopolymers. These materials, which provide long storage stability due to low oxygen permeability, are readily biodegradable. Efforts are also underway to develop a survival kit with the capability to convert environmental substrates into edible materials through the action of enzymes and/or microorganisms.

The Biohazard Assessment and Control Branch of the Biological Sciences Division studies the nutritional adequacy and stability of rations and the microbiological quality of military rations stored for varying lengths of time under a wide range of temperature and humidity levels. The research focus is on developing preservation systems that minimize oxidative events causing membrane damage during processing or storage. Other projects are directed toward developing a non-animal assay to aid in the selection of fats for use in energy-dense military foods, improved preservation techniques using a combination of controlled water activity, reduced oxygen tension, and regulation of ph to prevent microbial growth and extend shelf life in current and future combat ration components.

The primary contribution of the Physical Sciences Division to rations research is in the development of new or improved techniques for materials testing. Among other important contributions, the Physical Sciences Division has developed more sensitive as well as more precise methodology for measuring the amount of oxygen permeation of packaging materials. This Division also processes the capability to provide analytical support plus textural engineering via electron microscopy characterization of membranous materials used for encapsulating and packaging rations.

The Divisions within the Soldier Science Directorate work closely with each other, other product directorates at Natick and outside agencies. The Directorate, as well as the other Directorates previously discussed, maintains agreements with other federal agencies, academia, and industry for the pursuit of solutions to common perplexing scientific and engineering problems. The focus of all these efforts is to ensure that new rations, materials, and packaging processes are consistent with improving the total performance, health, and safety of today's and tomorrow's men and women in uniform, whether operating under peacetime training or extremely hostile combat conditions.

2. TECHNICAL OBJECTIVES

Natick's Food and Food Service Systems technology program is directed toward achievement of broad objectives that enhance the performance of each of the individuals comprising the Armed Forces in the field and improve the logistics of field feeding. The technology program supports a wide spectrum of field feeding scenarios for all of the Services, as well as garrison feeding operations. The Food and Food Service System technology areas include:

a. Operational Rations
b. Packaging Technology
c. Field Food Service Equipment
d. Combat Food Service Systems
e. Human Factors for Combat Rations

Our technical objectives in the Food and Food Service Systems area include:

a. Near Term (current to five years):

o New joint service family of operational rations providing enhanced acceptance and nutrition for all combatants while decreasing the overall logistics burden. Included are rations with self-heating capability, decreased weight/volume, as well as extended shelf-life rations for prepositioned war reserves.

o Technology advancements and system concepts for manpower and fuel efficient, lightweight field feeding equipment and systems enhancing mobility and combat readiness for specialized sensitive missions and/or extreme environmental conditions. Included are feeding systems for cold weather operations, Air Force Rail Garrison Mobile Missile System, and Navy galley enhancements.

o Technology demonstration of lightweight, compact, fuel-efficient food service equipment for field and shipboard feeding. Items will demonstrate significant Operations and Support cost savings through improvements in performance and reliability, as well as saving critical shipboard galley space, and field transportation assets (vehicles and trailers).

o Demonstration of specialized feeding systems required for critical strategic Department of Defense missions in Space Command mobile facilities and Strategic Air Command Missile Alert Stations. Feeding systems will enhance nutrition, morale, and crew alertness, contributing to overall readiness posture.

o Improved ration system for soldiers/airmen/sailors in survival situations. Utilizing advancements in food technology and packaging allowing extended extreme environment storage, as well as enhanced acceptability and nutrition, increasing morale and survival potential.

b. Mid Term (5 to 10 years):

o Field demonstration of advanced technologies in a Rapid Deployment Food Service Module providing a compact, self-contained, fuel-efficient field food preparation and distribution capability. Modular system capable of rapidly providing hot meals to field units up to company/battalion size, and transportable by any prevailing field transporter and compatible with any available fuel. Single energy source will support all food preparation functions. The system will be supplemented with a disposable, mini-module delivery system capable of enroute flameless ration heating for small/isolated groups.

o Advancements in subsistence by adapting biotechnological concepts of environmental nutrient extraction and individual water purification. The capability to obtain nutrients from environmental sources and to quickly chemically purify even salt water in the presence of microbial and chemical contaminants will significantly improve the warfighting capability of the individual soldier on the distributed battlefield of the future.

o Develop bioengineered degradable polymers as ration packaging systems capable of withstanding the storage/distribution environment required, including heat processing and extended shelf-life and of being degradable once the food products are consumed. Represents significant advancement in meeting the environmental concerns associated with plastic packaging waste.

o Demonstrate a ration shelf-life management system based on automated measurement of time/temperature profiles of items in storage. Automated system for use by all Services and Defense Logistics Agency will ensure highest quality rations are provided to the troops, will eliminate a large manpower requirement for inspection of stored rations, and will eliminate the potential for discarding rations unnecessarily soley because abusive storage conditions have been encountered.

o Demonstrate field feeding of fresh foods through the extension of the shelf life of field refrigerated items. Utilizing advanced food preservation technologies involving modified atmospheres, will demonstrate shelf-life extension permitting the use of fresh food in supply constrained situations. Provides the combat soldier with the highest possible quality food product.

o Using combat troops, demonstrate the utility of a tailorable ration system nutritionally and calorically customized for specific mission needs. System will reduce soldier vulnerability and sustain his combat effectiveness by providing readily utilizable food energy, by enhancing performance through the incorporation of selected natural ingredients, and by minimizing the load carrying burden. Ration packaging will resist environmental and battlefield threats while being biodegradable.

o Automated field feeding and ration distribution system concepts based upon artificial intelligence advancements and providing Operations and Support cost reduction by minimizing dedicated manpower and significantly reducing the logistics burden associated with ration distribution.

c. Long Term (10 to 20 years):

o Evaluation of autonomous field feeding systems capable of forming recognizable food products from basic ingredients. Advances in bioengineering, artificial intelligence and food forming will be applied to tailoring food to the individual/group based on environmental conditions and individual needs, optimizing nutrition for maximum performance.

o Evaluate the feasibility of extending mission duration through feeding system biofeedback mechanisms for individuals manning advanced weapons systems in encapsulated environments. Biofeedback capability and artificial intelligence will monitor individual's metabolism and automatically optimize nutrition/hydration. Allows the operator to maintain full mission posture for extended duration.

3. PROGRESS AND ACCOMPLISHMENTS

Natick is responsible for many Research, Development, Test, and Evaluation programs in all of our mission areas. Military relevance, quality of products, mission productivity, progressive management initiatives, and technical competence are synonymous with our programs, our staff, and our achievements. Through engineering for today, development for tomorrow, and research for the future, we provide the decisive edge for the American Soldier. We have, for example, focused our technology base programs on the technologies required for the next generation and future systems, while still addressing the chronic field feeding problems, emerging technologies, and required supporting capabilities.

We strive for major technological and system improvements of highest priority, user-relevant programs and timely fielding of these improvements. Our managers ensure the optimum use of resources to enhance productivity. Our researchers exploit worldwide technology to support activities and achieve technological superiority.

Examples of recent accomplishments in the Food and Food Service Systems area follow.

State of the Art Sulfite, Ascorbic Acid, and Nitrite Analysis Method. A quick, sensitive, and universal analytical method, using ion exclusion chromatography with electrochemical detection, was developed. The method has been applied for detecting and optimizing sulfite in foods, for measuring total Vitamin C, and for analyzing nitrite in cured products. A Natick scientist received a Department of Army Research and Development Achievement Award for his efforts in this area.

Control of Listeria. To have better control of the pathogenic Listeria Monocytogenes in our food supply, we succeeded in developing a rapid isolation (40 hours) and identification (8 hours) scheme. This rapid assay showed evidence of occurrence of Listeria in common refrigerated ready-to-eat foods, e.g. luncheon meats, soft cheeses, and seafoods. Careful monitoring of this pathogen is especially important in the extended logistics chain of the military commissary system.

Pouched Pizza and Burritos. A new technology was developed for stabilizing pouched pizza and burrito type products for long-term storage. This new technology involves strict control of the water activity and pH through the use of specialized ingredients including humectants and stabilizers, and incorporation of an oxygen scavenging system to reduce oxygen induced deterioration during storage. These items have been identified for incorporation in the menu design to continue to enhance the Meal-Ready-to-Eat (see fig. 1).

New Food Service System Concept for the Peacekeeper Rail Garrison System. The current basing concept for the MX missile is to house 18 maintenance people and security police in, essentially, a freight train car. They will work, eat, and sleep in this severely confined space, with no food service personnel assigned to the train. An applicable feeding concept was developed and was well received during a number of design reviews conducted by Air Force managers.

Pouched Bread for Meal, Ready-to-Eat Ration. The development of a shelf-stable, high quality, individually pouched bread product has been completed. The concept for use of anti-staling ingredients and an oxygen scavenger system to achieve long-term storage stability has been validated. First production test procurement of 832,000 pouches was completed. The pouched bread will be issued with the Meal, Ready-To-Eat (see fig. 2).

Dental Liquid Ration. Using an innovative dry-blending technology, a dental liquid ration has been developed that provides a five-day menu consisting of over 55 menu items for patients unable to eat solid food. This group includes patients with maxillo-facial injuries, cancer patients, patients with Alzheimer's Disease, as well as patients with a wide variety of throat and swallowing disorders. These items have been produced commercially on a Research and Development contract and will be tested in a field hospital environment. A cooperative Research and Development Agreement has been established to further develop this ration for joint military and civilian use (see fig. 3).

Ration, Lightweight, 30-Day. This ration has been adopted as a subsistence item for the Special Operation Forces. It provides a 2200 calorie, nutritionally balanced diet for reconnaissance and surveillance missions in extremely low weight/volume form (one lb, 45 cubic inches for one day's ration), allowing Special Operations Forces troops to carry 30 days supply of food in their rucksack without the necessity for subsistence resupply.

Meal, Ready-to-Eat Improvement Program. Significant technical challenges have been overcome to permit the development of shelf-stable items with a three-year shelf life, which address the desire of servicemen and women for fast foods, traditional/popular foods, and snack items. These include such items as: pizza, burritos, hamburgers and smoky hot dogs with buns, pork chow mein with crispy noodles, fried chicken, beef and fish, pound cake, fruit bars, potato sticks, pretzels, and other snack items. These items are being used to develop 12 new Meal, Ready-to-Eat menus for potential phasing into the Meal, Ready-to-Eat procurement cycle to bring to 24 the total number of possible menus. Of the 24, 12 would be purchased in any given year. Further, a new retort pouch material has been selected that provides improved performance at sub-zero temperatures, enhancing the utility of the Meal, Ready-to-Eat in cold environments.

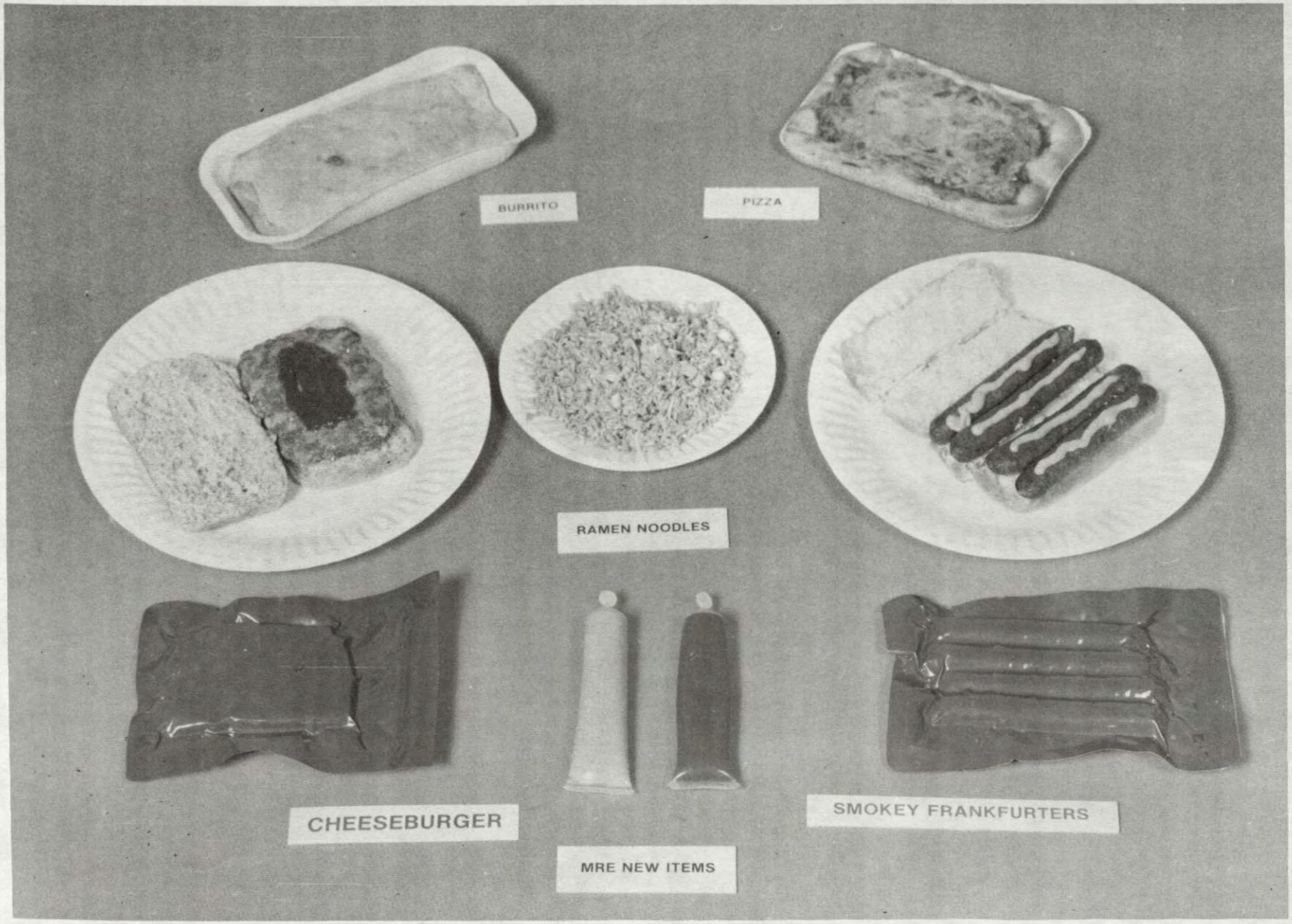

Figure 1. Pouched Pizza and Burrito

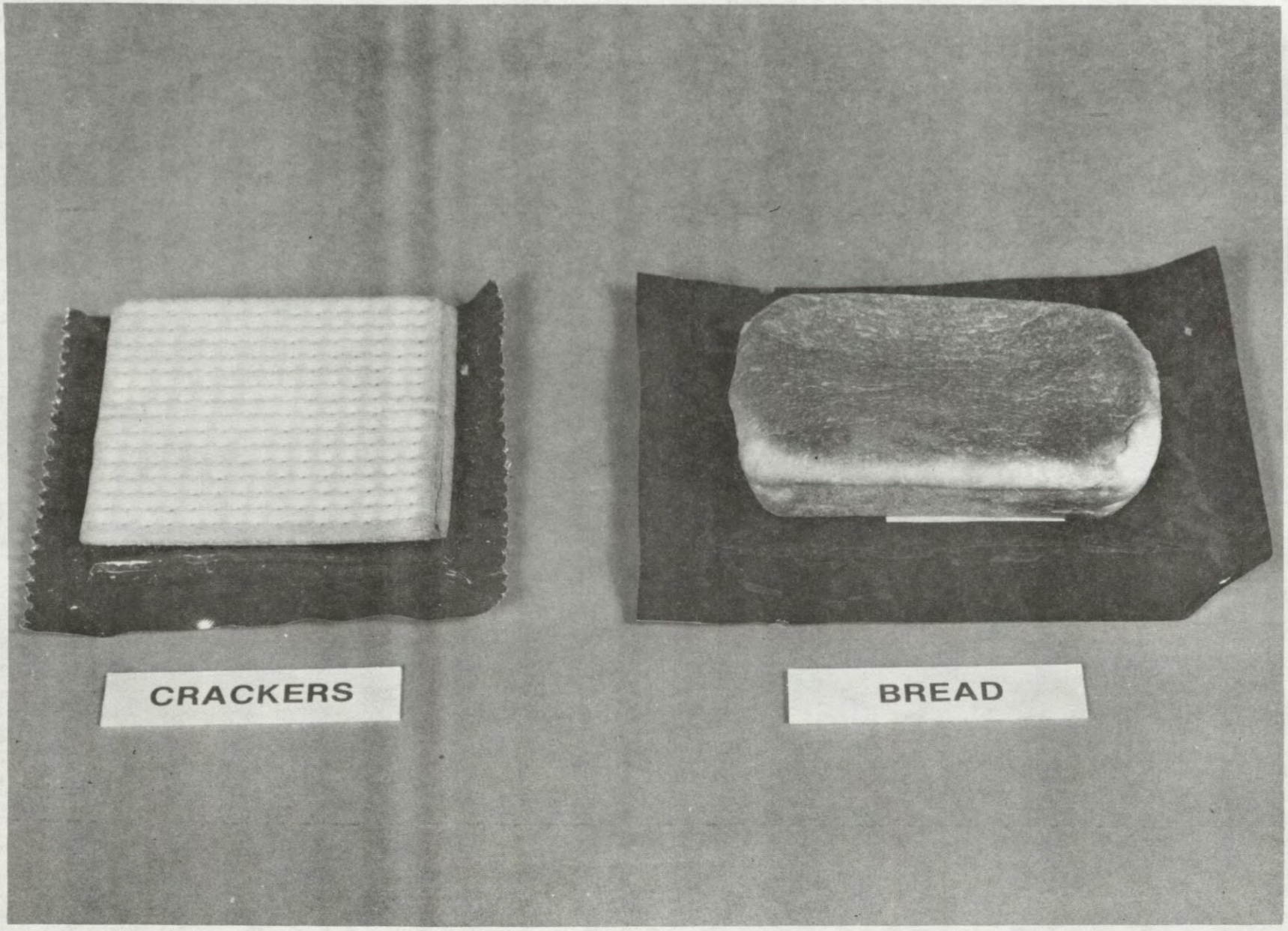

Figure 2. Pouched Bread for Meal, Ready-to-Eat Raion

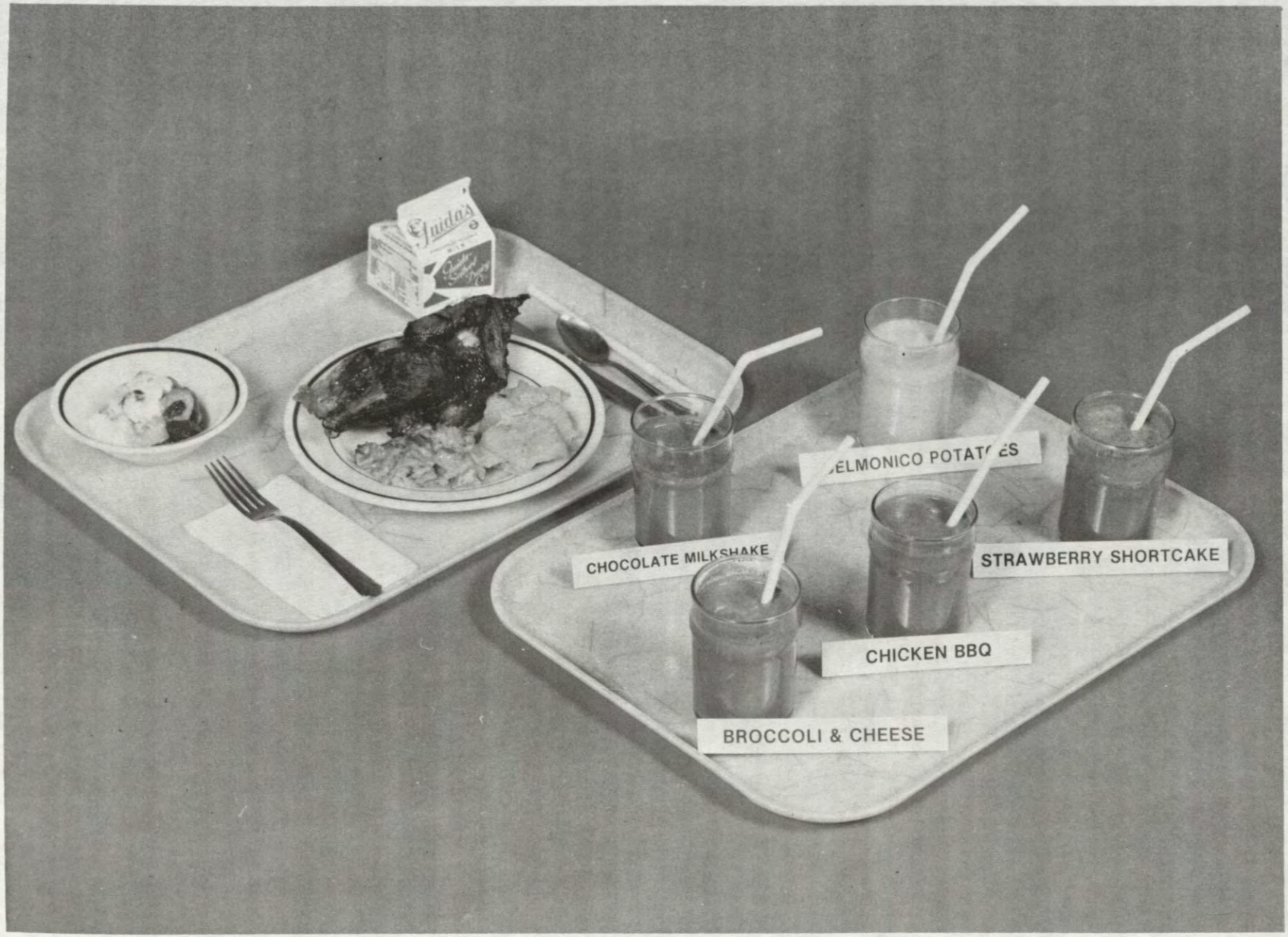

Figure 3. Dental Liquid Ration

Time-Temperature Indicator (TTI) for Meal, Ready-to-Eat Shelf-Life Determination. By attaching time-temperature sensitive labels to Meal-Ready-to-Eat cases being shipped to and stored in different parts of the world, and by scanning the Time-Temperature Indicator labels periodically, the remaining shelf-life of the Meal, Ready-to-Eat can be calculated. This system will ensure the appropriate rotation and consumption of military rations before significant changes have occurred.

Flameless Ration Heaters. A flameless, water-activated exothermic chemical heating pad has been successfully developed and demonstrated for heating Meal, Ready-to-Eat entrees (see fig. 4). This economical packet, which weighs approximately one ounce, on activation with two ounces of water, can heat an eight ounce entree in 12 to 15 minutes.

Mounted Ration Heating Device A major component of the Army Field Feeding System, the Mounted Ration Heating Device, was adopted as a standard item. This device, developed at Natick, provides Combat Vehicle Crews a safe, effective method to heat food and water using power from the vehicle electrical system. The system can heat four Meal, Ready-to-Eat entree pouches to 140°F within 20 minutes, or four disposable bags of water to 160°F within 40 minutes. It is compact and easily stows out of the way in the vehicle (see fig. 5).

4. PLANNED PROGRAM

With fiscal restraints, it is imperative that our research, technology, and development program efforts be prioritized to maximize our gains for the individual fighting men and women. To that end, therefore, our planned programs for fiscal year 1991 and 1992 will be focused on priority areas. Our major objectives include:

a. Research Program

(1) FY91 Planned Program

Exploit biotechnology concepts for combat feeding
Focal Point for Research Program:

1. Dr. Irwin A. Taub
   Telephone (508) 651-4711
   (All except Biotechnology)

2. Dr. David L. Kaplan
   Telephone (508) 651-5525
   (Biotechnology)

b. Technology Program

(1) FY91 Planned Programs

Complete Joint Services Front End Analysis of Pre-positioned War Reserve Materiel Stock Policy providing recommendations on how to reduce pre-positioning times and thereby increase combat ration quality.

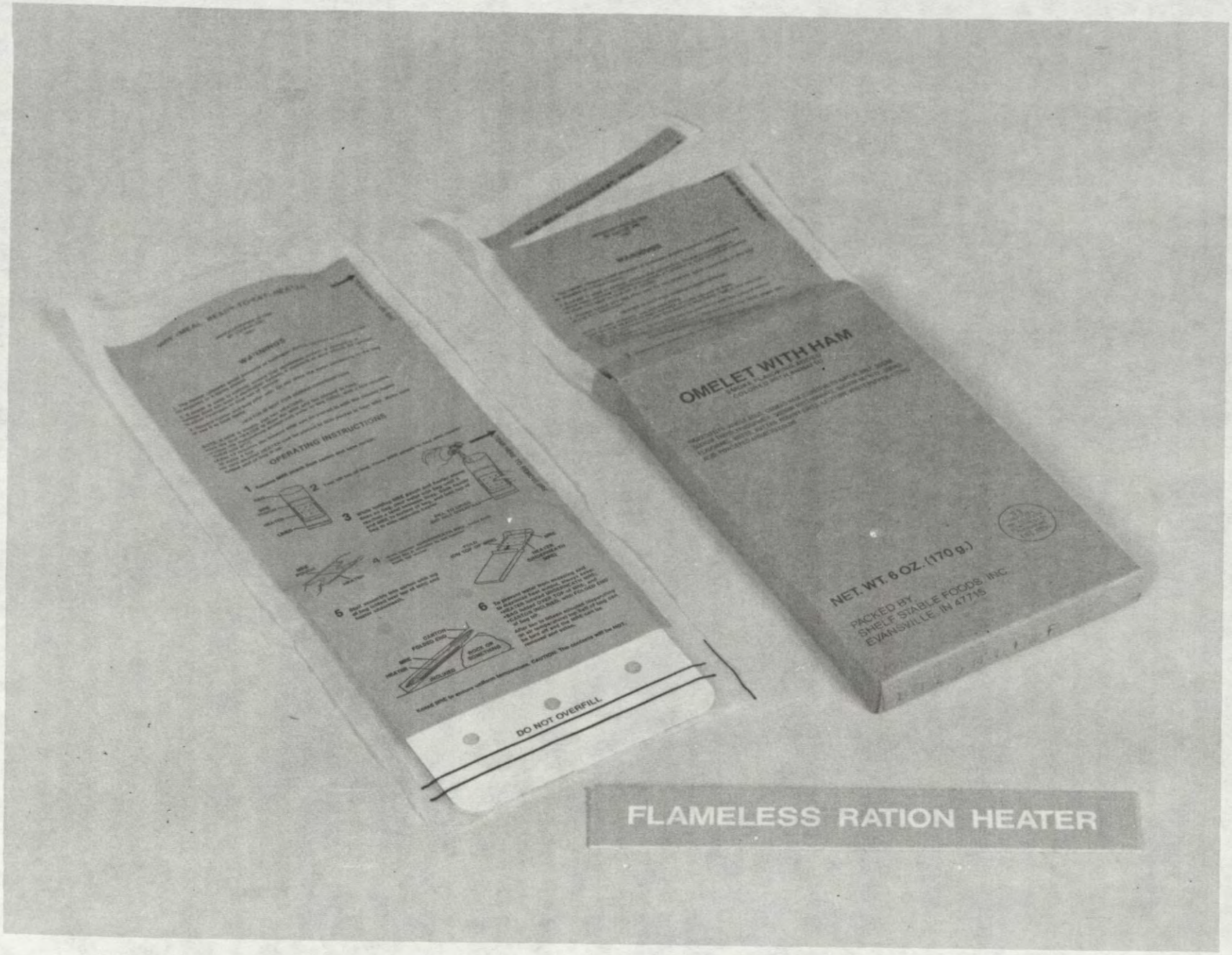

Figure 4. Flameless Ration Heater

Figure 5. Mounted Ration Heating Device

Complete exploratory development of Navy shipboard carbonated beverage tablet to reduce weight and bulk of beverage bases necessary to provide carbonated beverages on-board ships and transition to advanced development.

Complete exploratory development of Joint Service Cold Weather Feeding System concept aimed at improving cold weather food service operations and ensuring that hot, nutritious meals are available even in the extreme cold.

(2) FY92 Planned Programs

Complete concept feasibility studies and testing of a Tailorable Ration System.

Evaluate and demonstrate most promising Mobile Ration Preparation and Serving System concepts.

Complete exploratory development of Food Service System for Air Force units deployed in button-up conditions.

Complete concept development of a new high quality reconstituted milk product utilizing fat sources that will be significantly lower in saturated fats than the current product using tropical oils.

Focal Point for Technology Program:

Dr. Irwin A. Taub
Telephone (508) 651-4711

Mr. Gerald Darsch
Telephone (508) 651-4778

Mr. Paul Leitch
Telephone (508) 651-5068

c. Development Program

(1) FY91 Planned Program

Continue development of the Army High Mobility Field Kitchen, concentrating on refinement of the technical and operational requirements leading to the development of prototypes.

Conduct technical testing of advanced Family of Joint Operational Rations, taking advantage of state of the art advancements to improve soldier acceptance and nutrition as well as war reserve capabilities.

Conduct field testing of Navy Shipboard Frost Free Walk-In Refrigerators and Freezers.

Complete advanced development of a Long Life Ration Packet which will provide a multipurpose, lightweight, low volume ration for use in assault situation.

Conduct field testing of Joint Service Medical Field Food Service System.

Complete development of thermostabilized institutional size pouch and transition to Defense Personnel Support Center (DPSC). Shelf stable pouches all provide the capability to expand the variety of subsistence items for the Army Field Feeding System.

Design and develop improved food service equipment for Navy shipboard use, concentrating on commercial advanced, down-sized, multi-purpose equipment saving critical space and manpower.

Complete engineering development of improved heating of Meals, Ready-to-Eat in the field (Joint Service).

Complete the U.S. Marine Corps Combat Field Feeding System and transition to the Marine Corps for procurement.

(2) FY92 Planned Program

Complete development and transition to Defense Personnel Support Center the Joint Service New Generation Survival Ration improving the survival potential of individuals in extreme situations.

Complete development of the Dental Liquid Ration providing hospital patients with jaw/throat injuries with nutritious, acceptable meals, thereby speeding recovery and return-to-duty.

Conduct field testing of the High Mobility Field Kitchen (see fig. 6) providing a capability to cook, heat and serve a variety of rations at all levels of the battlefield.

Conduct user testing of a self heating tray-type ration for potential use in Marine Corps and Army operations.

Evaluate field food service equipment and system improvements for cold weather feeding operations.

Focal Points for Development Program:
1. Mr. Gerald A. Darsch
Telephone (508) 651-4778
For Food Rations
2. Dr. Gerald Hertweck
Telephone (508) 651-4064
For Food Service Equipment &
Systems

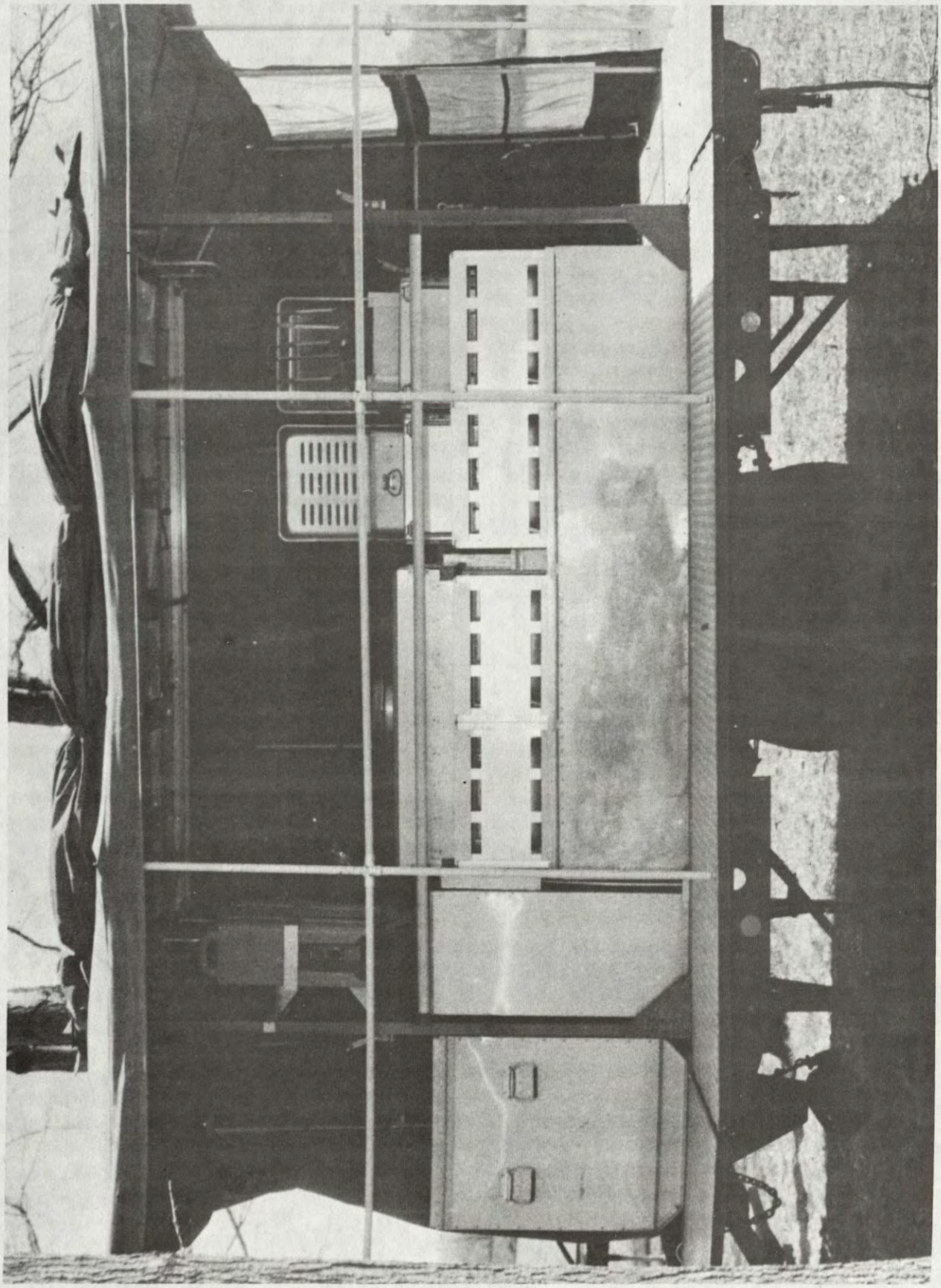

Figure 6. Our Present Mobile Kitchen Trailer

V. SCIENTIFIC AND TECHNICAL AREAS OF INTEREST

a. TECHNOLOGICALLY ADVANCED PACKAGED RATION SYSTEMS - Shelf-stable prepared foods are essential for enabling the individual soldier to perform assigned mission and to survive battlefield threats. The requirements for compactness, nutrition, acceptance, storage, protection, modularity, convenience, and producibility have become even more stringent in anticipation of supporting highly mobile, widely dispersed troops, possibly operating in an Nuclear Biological Chemical (NBC) environment.

Packaged ration functionality can be divided into the following physical and physiological areas:

(a) Storage
(b) Distribution
(c) Consumption
(d) Performance Maintenance

Specific Areas of Interest

A comparison of current capabilities versus future battlefield requirements dictates interest in the following major areas of scientific knowledge and technological capabilities:

- Scientific information and process technology are needed to ensure that nutrients required for optimum performance under stress are provided and utilized.

- Technology is needed to produce lightweight, nutrient-dense ration components that would be economically producible by industry.

- Scientific behavioral concepts are needed to encourage soldiers to consume rations that are unconventional in shape and appearance.

- Packaging technology based on nonfoil barrier material is needed to ensure protection against penetrants and to maintain integrity despite rough handling.

- Technology is needed to stabilize simultaneously many different meal components and to package them for rapid reheating.

Technical POC: Mr. Federick Costanza (Packaging) Tel: 508-651-4743.
Dr. Irwin A. Taub Tel: 508-651-4711.

b. COMBAT FOOD SERVICE EQUIPMENT - Efficient equipment and streamlined operating procedures that minimize the expenditure of energy, manpower, and material are essential for providing food service to troops in the field. The heating, chilling, and dispensing of food in future battlefields will require equipment made of lighter weight materials and having multi-fuel capability, higher energy efficiency and greater versatility. Sanitation and waste disposal concepts are also needed.

Food Service techniques and equipment must satisfy requirements for the following major functions:

- Cooking/Heating
- Chilled Storage/Transportation
- Dispensing
- Washing/Sanitation
- Disposing

Specific Areas of Interest.

Comparison of current capabilities versus projected Army requirements indicates the need for the following major areas of material and equipment technology:

- Material technology is needed to fabricate equipment using materials that provide required durability, strength, and convenience, while weighing and costing less than stainless steel.

- Combustion and energy conversion technologies are needed to enable field burners to operate more efficiently and safely, using multi-fuel energy sources.

- Energy conversion and networking technology is needed to optimize the generation and utilization of cogenerated electrical power.

- Cryogenic/refrigeration technology is needed to keep foods and beverages cold, with minimum expenditure of energy and limited demand for space.

- Cooking/heating technologies are needed to utilize electromagnetic, electrical, and thermal energy to prepare foods to serving temperature in differing container materials and shapes, under all tactical scenarios.

- Modular construction concepts are needed to design basic preparation and serving units that can be adopted or expanded for different uses, depending on tactics and threat conditions.

Technical POC: Mr. Donald Pickard Tel: 508-651-5036

c. COMBAT FIELD FEEDING SYSTEMS - An efficient combination of foods, food service equipment and supplementary supplies is needed to provide maximum flexibility to feed troops rapidly, under any climatic conditions, different battlefield threats, and all levels of commitment. Requirements for short setup and quick response times, for low reliance upon manpower, for easy transportability, for low dependence on fuel and water, and for adaptability to different levels of troop consolidation have become more stringent in anticipation of future battlefield scenarios.

Field feeding can be divided into the following major functional areas:

- Transporting
- Assembling
- Preparation
- Serving
- Remote Distribution
- Waste Handling
- Sanitation
- Maintenance

Specific Areas of Interest

Comparison of emerging capabilities versus projected requirements indicates interest in the following technical areas:

- Materials and engineering technologies are needed to maintain operability of equipment in severe cold and hot weather.

- Sanitation and material concepts are needed to protect foods during preparation, serving and distribution, and to sanitize food service equipment more efficiently and effectively.

- Technology is needed to develop efficient, lightweight, and compact refrigeration/freezer for delivery/storage of perishable food items in field feeding operations.

- Heat transfer technologies are needed for the efficient utilization of chemical or electrical energy in heating and warming foods.

- System design and configuration concepts are needed that optimize space, equipment, and manpower utilization and that maximize versatility, adaptability, efficiency, and effectiveness.

- Technology is also needed to reduce the weight and volume of food service equipment and associated shelters.

Technical POC: Dr. Gerald Hertweck. Tel: 508-651-4064

d. HUMAN FACTORS OF FOOD AND FEEDING SYSTEMS - Adequate food consumption and healthful food choices are required to ensure the long-term health and well-being of troops in garrison as well as when they are fed operational rations on the battlefield. The situation becomes more acute in the field than in garrison because climate, stress, limited time, unconventional foods and protective garments impinge on normal feeding patterns. There is the need to define the optimal feeding patterns and nutrients that can serve to enhance performance under these conditions.

Specific Areas of Interest

A comparison of current knowledge of food intake patterns and current and future feeding requirements in both garrison and field dictates interest in the following major areas:

- Sensory and psychophysical studies to determine the attributes (taste, smell, texture) required for acceptance and consumption of unconventional foods.

- Establishment of a database that uses simple laboratory measures to accurately predict food choice and consumption.

- Development of methods to modify food habits such as marketing strategies or behavioral modification approaches that result in healthful diets in garrison, and encourage food choices that optimize performance, and adequate consumption.

- Scientific understanding of the full range of environmental and social factors that affect food and water consumption.

- Identification of nutrients that enhance human performance under conditions of stress.

Technical POC: Dr. Edward S. Hirsch. Tel: 508-651-4522

VI. PROGRAM RELATIONSHIPS AND INTERACTIONS

a. Natick has significant interaction with other members of the Army Materiel Command Research, Development, and Engineering community.

U.S. Army Belvoir Research, Development and Engineering Center provides supporting expertise in mechanical water purification, electrical power generation systems, and environmental control.

U.S. Army Chemical Research, Development and Engineering Center provides expert advice regarding Chemical Biological protection and decontamination.

U.S. Army Materials Technology Laboratory provides expert input and support on materials technology, modeling of materials and composites, and corrosion analysis.

b. Natick has extensive interaction with the U.S. Army Research Institute of Environmental Medicine, located at Natick, on all ration technologies and systems being developed and in the field. U.S. Army Research Institute of Environmental Medicine nutrition expertise is critical to the enhanced performance expected with our future ration advancements.

c. Natick interacts with the other agencies in Department of Defense through the Food and Nutrition Research and Engineering Board and Joint Technical Staff. The DoD Food Program supports all of the Services.

In addition, there is a close liaison with Defense Logistics Agency and particularly its Defense Personnel Supply Center, the procuring activity for all Department of Defense rations. Natick is responsible for technical support for ongoing procurements.

There is a continuing interaction between Natick and the National Aeronautics and Space Administration in areas of mutual interest, particularly shelf stable and compressed food products.

d. Natick also interacts with other countries to share information on food and food service equipment technological advancements. Countries include Canada, Great Britain, Federal Republic of Germany, Australia, Korea, Japan, Israel, Norway, and Sweden.

e. Our interactions with industry and market surveillance are ongoing processes that are enhanced by the active participation of our official Natick representatives to many nongovernmental technical committees, and the active membership of Natick employees in the Research and Development Associates for Military Food and Packaging Systems, as well as various national scientific and technical association/societies such as the Institute of Food Technologists and American Society of Testing and Materials.

In addition, we formally interact with industry during several key events in the Research and Development life cycle, e.g., at the time of formulation of the requirement document, when conducting a market analysis, during the preparation of specifications and standards, and the preparation of standardization program analyses/plans.

f. We are also active participants in the Independent Research and Development Program, the Army Information for Industry Program (including the Army Potential Contractor Program, the use of Broad Agency Announcements and Advanced Planning Briefings for Industry), the Unsolicited Proposals Program, and the Small Business Innovative Research Program.

g. We also use the technical expertise available in the academic community. We participate in Intergovernmental Personnel Agreements. In addition, we interact with members of the academic community through participation in Research and Development Associates, the Combat Ration Advanced Manufacturing Technology Demonstration project at Rutgers University, and the Center for Advanced Food Technology at Rutgers which also involves many key industrial members.

h. We also interface early in the Research, Development, Test, and Evaluation process with various Training and Doctrine Command schools, particularly the Quartermaster School, the Infantry School, and the John F. Kennedy Special Warfare Center and School, and maintain close coordination with these schools throughout the development process.

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-90/055 in the series of reports approved for publication.

VII. APPENDIX

Food and Food Service Systems - Next Generation and Future Systems

It is planned that in the future approximately 50 percent of our technology base resources (6.1 basic research, 6.2 exploratory development, and 6.3a proof-of-principle demonstration) will be allocated in support of specific Next Generation and Future Systems. Next Generation Systems are the systems that will begin full-scale development in the 1990s and will provide a fielded capability into the 21st century. Future Systems are capabilities that would potentially be developed in the early 21st century. For each system, the enabling technologies have been identified that could allow achievement of the capabilities desired. Programs and proof-of-principle demonstrations of prototypes (technology demonstration) have been structured in a logical, time-phased manner. The next generation and future systems are as follows:

Rapid Deployment Food Service System
Combat Field Feeding System Army 21
Family of Joint Operational Rations (Proposed)

TITLE: Rapid Deployment Food Service System

KEY FEATURES:

- o Highly mobile, durable, and versatile
- o Compact, self-contained, and energy-efficient
- o En route, flameless ration heating for small or isolated units
- o Acceptable, hot meals
- o Assurance of nutritional sustainment
- o Minimum staffing

SYSTEM DESCRIPTION: A compact, self-contained, fuel-efficient field food preparation and distribution module capable of rapidly providing hot meals to field units up to company size. Module will be sized and configured for transport by any prevailing field transporter, and will be compatible with any available fuel. A single energy source will support all food preparation functions. The basic module will be supplemented by a disposable, mini-module delivery system capable of en route flameless ration heating to support small or isolated groups (four to twelve persons).

OPERATIONAL NEED: To provide hot, acceptable food to groups of combatants regardless of climatic or geographic conditions, operational scenarios, or immediate battlefield deployment so as to assure peak physical and mental performance.

	Baseline (Current)	Proposed
Transport Platform	Dedicated 1 1/2 Ton Trailer	Common Pallet Base
Deployment Versatility	Trailer Bed	Trailers or Shelters
Equipment Weight	3000 lb	1200-1500 lb
Energy Source(s)	6	1
Fuel Versatility	Gasoline Only	Multifuel
Off-Site Delivery	Insulated Only	En Route Heating
Staffing	4	2

The proposed system provides significantly enhanced versatility, mobility, and flexibility in theater movement and use. These enhancements, in turn, provide an increased assurance that the nutritional and related needs of combatants are met.

ENABLING TECHNOLOGIES:

Decision Support Systems Technologies

Heavy Duty Ground Vehicle Technology

Vehicular Survivability Technology

Polymeric Materials Technology

Electrochemical Energy Conversion Technology

Direct Conversion Technology

Preparation/Service

Power Conversion

Human Factors Engineering

Improved Materials

TECHNICAL OBJECTIVES:

- Highly mobile, compact, self-contained food preparation and distribution module for field use
- Energy networking by heat pipe technology or power cogeneration
- Lightweight, multifunctional, energy-efficient food service equipment
- Lightweight, flameless heating of rations through electrochemical reactions or catalytic combustion

- o Self-powered, multifuel-fired, field burner systems
- o Optimization of equipment energy usage in the food preparation module
- o Improved durability and battlefield survivability

ECHELON OF EMPLOYMENT: Division to Platoon

AREA OF EMPLOYMENT: Near enemy lines and in remote sites

PERFORMANCE GOALS:

- o Assure mission performance of combatants
- o Improve frequency of hot meals served under field conditions
- o Improve transportability, mobility, and operational versatility
- o Minimize logistics support burden
- o Reduce number of combat support personnel
- o Improve survivability of basic food service functions

SURVIVABILITY AND/OR COUNTERMEASURE ISSUES:

- o Reduced thermal signature
- o Decontamination following Nuclear Biological Cover exposure

COMMENTS: Several technologies relating to making equipment multifunctional and energy-efficient and to automating the food preparation functions will be completed sooner if funds are available for exploiting new materials and new heating concepts and for adapting microprocessor devices in food service operations.

NATICK POINT OF CONTACT:

Irwin Taub
(508) 651-4711

TITLE: Combat Field Feeding System - Army 21

KEY FEATURES:

- Nutritionally tailored to enhance performance
- Lightweight and compact
- Interoperable ration mix
- Easy adaptation for mounted/dismounted troops
- Optimized for acceptance and consumption
- Flameless, heat-on-the-move capability
- Modular, energy-efficient food preparation module

SYSTEM DESCRIPTION: An advanced subsistence support system that, by using a three-subsystem family of tailorable operational rations, is adaptable to all situations and environments encountered by individuals or groups. One subsystem provides an eat-on-the-move, compact individual ration nutritionally tailored to enhance physical/mental performance. Another provides a self-heating meal module made with familiar components and suitable for small groups in remote areas. The third provides familiar foods to mounted or dismounted groups, using automated food service modules that are operable with minimum energy and manpower resources and under high mobility and NBC conditions.

OPERATIONAL NEED: Readily adaptable, highly acceptable, and lightweight rations that provide soldiers with scenario-specific nutrients enabling them to function at peak performance while operating on a self-sustained basis for extended periods on the non-linear and highly mobile future battlefield.

	Baseline (Current)	Proposed
Caloric Density	0.8 Calories/cc	4.5 Calories/cc
Ration Volume	3000 cc	800 cc
Tailoring	None	Extensive
Performance Enhancement	None	Some
Fuel Versatility	Gasoline	Solar + Fossil
Auxiliary Power	None	500 Watts/unit

The proposed new system represents a significant enhancement in capability, particularly with respect to mobility and performance, and offers tactical opportunities not previously considered possible, because of the logistic simplicity and adaptation to different scenarios.

Combat Field Cont'd

ENABLING TECHNOLOGIES:

Polymeric Materials Technology	Rations
Biotechnology	Preservation
Advanced Composites and Ceramics Technology	Preparation/Service
Direct Conversion Technology	Expert System, AI Technology
Decision Support Systems Technology	Human Factors Engineering
Deep Submergence Vehicle Technology	Improved Materials

TECHNICAL OBJECTIVES:

- o Tailored components, modules, and rations for specific scenarios
- o Highest possible nutrient dense component consistent with high soldier acceptance
- o Durable, impermeable ration packaging materials and on-package contamination detector
- o Incorporation of performance-enhancing natural ingredients
- o Biotechnology-based sustenance extraction kit
- o Lightweight, flameless heating through water activated reaction or catalytic combustion
- o Automated, highly transportable food preparation and dispensing module
- o Lightweight, multifunctional, multifuel-compatible, self-powering, and energy conservative food equipment
- o Readily interoperable and intermixable rations and food delivery systems

ECHELON OF EMPLOYMENT: Division to Individual Soldier

AREA OF EMPLOYMENT: Near, in (intermingling), and behind enemy lines

Combat Field Cont'd

PERFORMANCE GOALS:

- o Operate flexibly and responsively to different tactical and climatic situations
- o Reduce reliance upon many different rations (survival to arctic)
- o Simplify and minimize logistics burden
- o Enhance effectiveness of individuals in long duration, isolated situations
- o Enhance morale of dismounted troops
- o Reduce number of combat service support personnel
- o Reduce consumption of fuel and power in delivering meals to groups
- o Enable individuals to operate under stress without performance degradation
- o Enable tactical forces to subsist without resupply for extended periods
- o Utilize land- or ocean-based systems for storage of consumables

SURVIVABILITY AND/OR COUNTERMEASURE ISSUES:

- o Exploitation of the environment, if applicable
- o Interdiction of mobile food delivery system

COMMENT: Several technologies relating to enhancing individual performance and to streamlining mobile food modules will be completed sooner if funds are provided for concurrent, complementary efforts involving other Army and non-government laboratories. -- The Soldiers' Command

NATICK POINT OF CONTACT:

Jack Briggs
(508) 651-4561